Nuclear Operating Company
South Texas Project Electric Generating Station P.O. Box 289 Wadsworth, Texas 77483

February 13, 2003
NOC-AE-03001465
10CFR50.73

U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
One White Flint North
11555 Rockville Pike
Rockville, MD 20852

South Texas Project
Unit 2
Docket No. STN 50-499
Licensee Event Report 02-004
Turbine Blade Failure

Pursuant to 10CFR50.73, South Texas Project submits the attached Unit 2 Licensee Event Report 02-004 regarding a turbine blade failure that occurred on December 15, 2002. This event did not have an adverse effect on the health and safety of the public.

Corrective actions 3, 4 and 5 are the only commitments in this event report. A supplement to this report will be submitted by July 1, 2003 to address additional relevant information.

If there are any questions on this submittal, please contact S. M. Head at (361) 972-7136 or me at (361) 972-7849.

E. D. Halpin
Plant General Manager

kaw

Attachment: LER 02-004 (South Texas, Unit 2)

IE22

cc:

(paper copy)

Ellis W. Merschoff
Regional Administrator, Region IV
U.S. Nuclear Regulatory Commission
611 Ryan Plaza Drive, Suite 400
Arlington, Texas 76011-8064

U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
One White Flint North
11555 Rockville Pike
Rockville, MD 20852

Richard A. Ratliff
Bureau of Radiation Control
Texas Department of Health
1100 West 49th Street
Austin, TX 78756-3189

Cornelius F. O'Keefe
U. S. Nuclear Regulatory Commission
P. O. Box 289, Mail Code: MN116
Wadsworth, TX 77483

C. M. Canady
City of Austin
Electric Utility Department
721 Barton Springs Road
Austin, TX 78704

(electronic copy)

A. H. Gutterman, Esquire
Morgan, Lewis & Bockius LLP

L. D. Blaylock/W. C. Gunst
City Public Service

Mohan C. Thadani
U. S. Nuclear Regulatory Commission

R. L. Balcom
Texas Genco, LP

A. Ramirez
City of Austin

C. A. Johnson/A. C. Bakken III
AEP - Central Power and Light Company

Jon C. Wood
Matthews & Branscomb

NRC FORM 366 (7-2001) | U.S. NUCLEAR REGULATORY COMMISSION | APPROVED BY OMB NO. 3150-0104 | EXPIRES 7-31-2004

LICENSEE EVENT REPORT (LER)

(See reverse for required number of digits/characters for each block)

1. FACILITY NAME	2. DOCKET NUMBER	3. PAGE
South Texas Unit 2	05000 499	1 OF 4

4. TITLE
Turbine Blade Failure

5. EVENT DATE			6. LER NUMBER			7. REPORT DATE			8. OTHER FACILITIES INVOLVED	
MO	DAY	YEAR	YEAR	SEQUENTIAL NUMBER	REV NO	MO	DAY	YEAR	FACILITY NAME	DOCKET NUMBER 05000
12	15	2002	2002 -	04 -	00	02	13	2003	FACILITY NAME	DOCKET NUMBER 05000

9. OPERATING MODE	1
10. POWER LEVEL	100

11. THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR ': (Check all that apply)

	20 2201(b)		20.2203(a)(3)(ii)		50.73(a)(2)(ii)(B)		50.73(a)(2)(ix)(A)
	20 2201(d)		20.2203(a)(4)		50.73(a)(2)(iii)		50.73(a)(2)(x)
	20.2203(a)(1)		50.36(c)(1)(i)(A)	X	50.73(a)(2)(iv)(A)		73.71(a)(4)
	20.2203(a)(2)(i)		50.36(c)(1)(ii)(A)		50.73(a)(2)(v)(A)		73.71(a)(5)
	20.2203(a)(2)(ii)		50.36(c)(2)		50.73(a)(2)(v)(B)		OTHER Specify in Abstract below or in NRC Form 366A
	20.2203(a)(2)(iii)		50.46(a)(3)(ii)		50.73(a)(2)(v)(C)		
	20.2203(a)(2)(iv)		50.73(a)(2)(i)(A)		50.73(a)(2)(v)(D)		
	20.2203(a)(2)(v)		50.73(a)(2)(i)(B)		50.73(a)(2)(vii)		
	20.2203(a)(2)(vi)		50.73(a)(2)(i)(C)		50.73(a)(2)(viii)(A)		
	20.2203(a)(3)(i)		50.73(a)(2)(ii)(A)		50.73(a)(2)(viii)(B)		

12. LICENSEE CONTACT FOR THIS LER

NAME	TELEPHONE NUMBER (Include Area Code)
Kathleen A. Work	361-972-7936

13. COMPLETE ONE LINE FOR EACH COMPONENT FAILURE DESCRIBED IN THIS REPORT

CAUSE	SYSTEM	COMPONENT	MANU-FACTURER	REPORTABLE TO EPIX	CAUSE	SYSTEM	COMPONENT	MANU-FACTURER	REPORTABLE TO EPIX

14. SUPPLEMENTAL REPORT EXPECTED				15. EXPECTED SUBMISSION DATE	MONTH	DAY	YEAR
X	YES (If yes, complete EXPECTED SUBMISSION DATE)		NO		07	01	2003

16. ABSTRACT (Limit to 1400 spaces, i e., approximately 15 single-spaced typewritten lines)

At 1808 hours on December 15, 2002, Unit 2 was at 100% power when it was manually tripped due to excessive vibration in Low Pressure Turbine 22. Subsequent investigation identified that a blade had cracked and broken off and was ejected from the low pressure turbine into the condenser. Additional cracked blades were found in Low Pressure Turbines 22 and 23.

The cause of the blade cracking is High Cycle Fatigue. Corrective actions include repairing the Unit 2 rotor system and damaged blades, installing vibration monitoring equipment, evaluating the data taken during and after the Unit 2 restart and modifying the root cause as necessary.

This event resulted in no personnel injuries, offsite radiological releases or damage to safety related equipment. There were no challenges to plant safety and the plant responded as expected.

1. FACILITY NAME	2. DOCKET	6. LER NUMBER			3. PAGE
		YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	
South Texas Unit 2	05000 499	2002	04	00	2 OF 4

NARRATIVE *(If more space is required, use additional copies of NRC Form 366A)* (17)

DESCRIPTION OF EVENT

On December 15, 2002, at 1808 hours, Unit 2 was manually tripped due to excessive vibration in the low pressure turbine. A visual inspection revealed that a blade had been ejected from low pressure turbine 22 and was found in the condenser. The ejected blade came from the last row of blades (L-0 blade row) prior to the condenser.

Unit 2 had just completed an outage (2RE09) and the unit had been returned to 100% power on December 10, 2002. The outage encompassed steam generator replacement, power uprate from 3800 MWT to 3853 MWT, and replacement of the main generator rotor.

Based on the initial visual inspection after the blade was ejected, further inspections were performed which revealed additional cracking in the low pressure turbines 23 and 23. Low pressure turbines 22 and 23 had been inspected during the previous outage (2RE08) per our inspection plan. Two cracks were found on low pressure turbine 23 and were repaired at that time. The failure analysis determined the blade cracking found during 2RE08 and during this event were both caused by High Cycle Fatigue (HCF). The cracks were thought to have been initiated from manufacturing flaws. All other blades on these two rotors were inspected with no problems identified due to HCF.

Repairs were made on all of the cracked blades found on the low pressure turbines as a result of this event. In addition, a Blade Vibration Monitoring System (BVMS) and Torsional Vibration Monitoring System (TVMS) were installed on Unit 2. Thirty seven days after the initial event, Unit 2 was safely restarted and reached 100% power on January 23, 2003 at 1502 hours. At 1617 on January 23 power was reduced due to unacceptable torsional vibration readings and on January 24, 2003, Unit 2 was taken off-line again. The turbine was inspected and additional cracked blades were found.

Repairs are ongoing in Unit 2. A supplement to this report will be issued following the restart of Unit 2.

EVENT SIGNIFICANCE

This event resulted in no personnel injuries, radiation exposure, offsite radiological releases or damage to important safety related equipment. The event is reportable pursuant to 10CFR50.73(a)(2)(iv)(A) because it resulted in a condition that resulted in manual or automatic actuation of the reactor protection system.

This event was not risk significant for nuclear safety. The PRA group has determined that the Conditional Core Damage Probability (CCDP) for a turbine trip event is calculated by dividing the core damage frequency by the initiating event frequency, or CCDP = 2.91E-07/1.09 and CCDP = 2.68E-07. This result is typical for general transient initiating events and is not risk significant. It is less than the 1E-06 limit in Regulatory Guide 1.174, An Approach for Using Probabilistic Risk Assessment in Risk Informed Decisions on Plant Specific Changes to the Licensing Basis, judged acceptable for risk-informed decisions. The Conditional Large Early Release Probability (CLERP) is: LERF contribution divided by IE frequency, or 1.3065E-08/1.0875. CLERP = 1.20E-08 which is also well below the NRC limits identified in RG 1.174.

CAUSE OF EVENT

The cause of the L-0 blade root cracking is high cycle fatigue. High cycle fatigue is driven by high alternating stresses at the L-0 blade root area. Based on Unit 2 startup testing and investigation into the Unit 2 failures, high torsional vibrations are the cause of the alternating stresses at the L-0 blade roots. There are two causes of the high torsional vibrations in Unit 2. The causes are discussed below:

1. FACILITY NAME	2. DOCKET	6. LER NUMBER			3. PAGE
		YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	
South Texas Unit 2	05000 499	2002	04	00	3 OF 4

NARRATIVE *(If more space is required, use additional copies of NRC Form 366A)* (17)

1. The entire rotor train has several vibration modes that reside near 120 Hz (modes 19-24). These modes were considered by the vendor to be non-excitable modes. The design of the rotor system is such that the frequencies near 120 Hz were known, but not considered to be sensitive to excitations in the rotor train. During normal turbine generator operation there are steady state excitation forces that occur at twice the electrical frequency (120 Hz). These forces result from unbalanced transmission system voltages. These forces are known as negative phase sequence currents and act upon the generator rotor via the generator stator through the air gap. The forces create torque in the opposite direction of normal generator rotation.
2. During 2RE09, a new main generator rotor was installed in Unit 2. During fabrication, the new rotor slots were machined incorrectly and therefore the rotor is not identical to the original generator rotor. In addition, the new generator rotor has additional slots that have been filled with filler material and the slots are slightly offset from original design.

   Based on the ejected blade's fracture surface, startup testing and investigation, the alternating stress before and after 2RE09 has changed significantly. Prior to 2RE09, there were torsional vibration amplitudes that propagated very small cracks initiated as early as a March 2001 negative phase sequence event. In addition, based on the number of cracked blades found after 2RE09 and the full NDE during 2RE08, the torsional vibration amplitude was likely to have initiated cracks during cycle 9. After 2RE09, the data clearly shows the alternating stress is much higher and cracks are initiating and propagating very quickly at the blade roots. The higher stress is clearly shown on the blade fracture surface where before 2RE09 the crack has numerous beach marks. After 2RE09, the crack surface shows clear ratchet marks and few or no beach marks indicating a new constant and higher alternating stress. With the new generator rotor installed, the same or similar electrical forcing function (negative phase sequence currents) is not being similarly dissipated in the train and is resulting in excessive torsional amplitudes. The torsional vibration response was seen immediately after the main generator breaker closure.

CORRECTIVE ACTIONS

1. A blade vibration monitoring system was installed in Unit 2. This action was completed on January 19, 2003.
2. A torsional vibration monitoring system was installed in Unit 2. This action was completed on January 19, 2003.
3. Repairs are being made to the cracked blades found in the Unit 2 low pressure turbines. These repairs will be completed prior to restart of Unit 2.
4. Modifications and repairs are being made to the Unit 2 rotor system to make it less sensitive to excitations in the rotor train. These repairs will be completed prior to restart of Unit 2.
5. Data taken during and after the Unit 2 restart will be evaluated and the root cause, along with required corrective actions, of the turbine blades cracking will be modified as necessary. This action will be completed by May 1, 2003.

1. FACILITY NAME	2. DOCKET	6 LER NUMBER			3. PAGE
		YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	
South Texas Unit 2	05000 499	2002	04	00	4 OF 4

NARRATIVE *(If more space is required, use additional copies of NRC Form 366A)* (17)

ADDITIONAL INFORMATION

A search of industry operating experience found the following six events involving turbine blade failures that appear that they could be similar to our event (i.e., a blade was ejected and the cause was probably due to torsional vibration or off-normal operating conditions):

Plant	Month of Blade Failure
Maanshan (Taiwan)	July 1985
Indian Point 3	July 1986
North Anna 1	August 1986
Susquehanna 1	July 1993
Palisades	July 1997
Diablo Canyon 1	November 2000

Operating experience information also shows that, since July of 1998, Comanche Peak 2 has needed to downpower each summer because the BVMS blade vibration amplitude goes above the alert level. Comanche Peak 1 is not affected by these high vibrations.